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**Research Paper
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Service Life of Treated and Untreated Black Hills Ponderosa Pine Fenceposts

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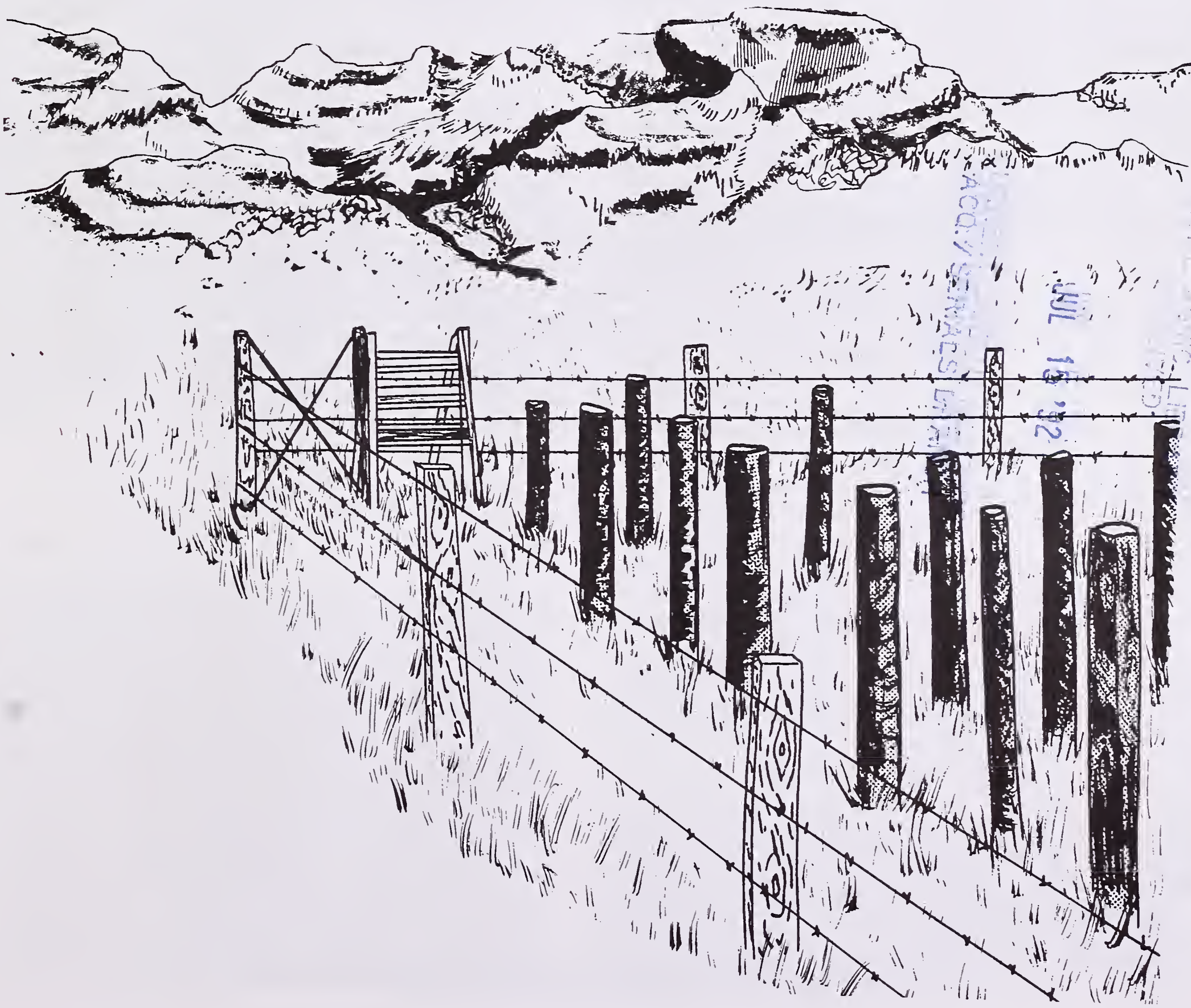

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Service Life of Treated and Untreated Black Hills Ponderosa Pine Fenceposts

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Abstract

Service-life tests indicate that ponderosa pine fenceposts treated with preservatives performed well after field exposure of 30 years. Treating plants in the Black Hills area used commercial methods to treat the posts with creosote, pentachlorophenol, and waterborne arsenicals. Test sites were in the northern Great Plains—one in the semiarid western portion near Scenic, South Dakota, the other in the more humid eastern portion near Brookings. The annual service cost of the untreated posts ranged from $1.06 to $1.18 per post depending upon test plot location. The lowest annual cost of the treated posts was $0.85 per post.

[1]*Headquarters is in Fort Collins in cooperation with Colorado State University*

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Management Implications

The market for fenceposts produced in the Black Hills area possibly can be expanded by demonstrating that the service life of posts can be extended with preservative treatment. Expanded post markets could provide more outlets for small roundwood and could enhance local economies through sales of unutilized tree resources. Forest management in the area has been and continues to be hindered by a less than adequate demand for timber products from small roundwood.

Introduction

During 1960 and 1961, ponderosa pine (*Pinus ponderosa*) fenceposts were installed on two test sites in the northern Great Plains—one in the semiarid western portion near Scenic, South Dakota, and the other in the more humid eastern portion near Brookings. The tests were designed to determine the service life of the posts, to evaluate the effectiveness of various preservatives and retention levels, and to demonstrate commercially treated posts. Both pressure- and nonpressure-treated posts were compared with untreated (control) posts. The posts were cut from timber stands in the Black Hills. Twelve treatment combinations of chemicals, pressures, and retention levels were tested along with untreated controls (table 1). Initial results of the service test were reported in progress reports by Markstrom and Clark (1975) and Markstrom (1984). This paper describes the treating procedures and the results of the 30-year service test.

Methods

Test Sites

The semiarid test site near Scenic, SD, on the Wall Ranger District of the Nebraska National Forest, has two plots; one is well drained, the other poorly drained (figs. 1–3). The humid site near Brookings, located on South Dakota State University land, has one plot (fig. 4). A total of 975 ponderosa pine fenceposts were set 2.5 feet deep on three rectangular plots. Each plot contains 325 posts, with 13 posts in each of 25 rows. One post from each treatment and retention level and one untreated post were randomly located within each row. This rectangular arrangement is more advantageous than a line fence for comparing preservative treatments, because the posts are exposed to more uniform soil and drainage conditions. Drifting snow, however, tends to accumulate within the rectangular plots. Trapped snow may increase soil water content and possibly increase decay in the posts.

Treatments

All test posts were 6.5 feet long and machine peeled, with the following characteristics:

	Mean	Range
Diameter, small end (inches)	3.6	3.0–4.4
Sapwood thickness (inches)	1.5	0.2–2.1
Growth rate (rings/inch)	18	7–45

Local treating plants used commercial methods of 30 years ago to treat the posts (table 1), and usually placed them in the same charge with other products. In some charges the volume of test posts amounted to only 3% of the total volume being treated. Average calculated retentions for most treatments differed substantially from the target retentions, possibly because other posts or products in the same charge may not have uniformly absorbed the target amounts of preservative. Details on the treating procedures and chemical composition of each preservative are discussed in the appendix.

The retention level of each post treated with oilborne preservatives (PC, PP, H&CC, CSP, VP) was calculated as follows:

$$Y = \frac{W(100 + M_1) - X(100 + M_2)}{Z(100 + M_1)}$$

where

Y = retention of preservative (lb/ft^3)
W = weight of treated post (lb)
X = weight of untreated posts at time of moisture-content determinations on sample post (lb)
Z = volume of post (ft^3)
M_1 = average moisture content, ovendry weight, of five sample posts before treatment (%)
M_2 = average moisture content, ovendry weight, of five sample posts after treatment (%).

Retention of the posts treated with the waterborne Osmosalts (PO) was calculated as follows:

$$Y = \left(\frac{W-X}{Z}\right) C$$

where Y, W, X, and Z = same as above, and C = concentration of solution (lb of Osmosalts/lb of solution).

Osmosalts are currently listed as a fluor chrome arsenate phenol, type B (FCAP-typed B) waterborne preservative. In this study, retention of the Osmosalts is based on both the solid preservatives absorbed by the posts and the oxide retentions.

Table 1.—Commercial methods used to treat posts with target preservatives and average chemical retentions[1] and sapwood penetration.

Treatments[2]	Retention		Sapwood penetration	Treatment code
	Target	Average		
	-------- Lb/ft --------		Percent	
PRESSURE TREATMENTS:				
PC—50% petroleum distillate and 50% coal tar creosote	3 6	8.10 8.60	82.0 100.0	PC-8.1 PC-8.6
PP—5% pentachlorophenol in petroleum oil[3]	6 (0.30)	7.10 (0.36)	100.0	PP-7.1
PO—Osmosalts[4]	0.35 (0.21) .55 (0.33)	0.41 (0.25) 0.63 (0.38)	62.0 64.0	PO-0.41 PO-0.63
NONPRESSURE TREATMENTS:				
H&CC—Hot and cold bath in 100% coal tar creosote	3 6	7.10 9.60	51.0 81.0	H&CC-7.1 H&CC-9.6
CSP—Cold soak, 5% pentachlorophenol in petroleum oil[3]	3 (0.15) 6 (0.30)	3.90 (0.20) 5.60 (0.28)	80.0 93.0	CSP-3.9 CSP-5.6
OMS—Osmoplastic,[4] butt dip only	—	—	18.7	OMS
VP—Vacuum, 5% pentachlorophenol in petroleum oil[3]	3 (0.15) 6 (0.30)	3.00 (0.15) 4.70 (0.24)	72.0 89.0	VP-3.0 VP-4.7

[1]*Numbers in parenthesis represent retentions based on oxides.*

[2]*The term pressure indicates that pressure beyond that of the atmosphere was applied to the preservative during treatment; vacuum indicates that a partial vacuum was drawn and held on the posts before the preservative was introduced under vacuum.*

[3]*Retention values include the weight of the solvent.*

[4]*Osmosalts, as described by the manufacturer, contains: sodium fluoride, 33.0%; disodium arsenate, 25.0%; sodium bichromate, 32.3%; dinitrophenol, 6.3%. Osmoplastic compound contains: sodium fluoride, 43.7%;dinitrophenol, 3.1%; potassium bichromate, 2.0%. Solvent in Osmoplastic compound was Avenarius Carbolineum supplied by the Carbolineum Wood Preserving Company. Trade and company names are used for the benefits of the reader, and do not imply endorsement or preferential treatment by the U.S. Department of Agriculture.*

Figure 1.—The poorly drained plot in the semiarid area near Scenic, South Dakota, is in the background (arrow). Note elevation and drainage differences. Normal annual precipitation averages about 15 inches and annual temperature about 49°F.

Figure 2.—The poorly drained plot near Scenic has a clay soil with pH of 8.2. Note that soil has washed into the plot from the surrounding area.

Figure 3.—The well-drained plot near Scenic has a clay soil with pH of 7.4. This plot has no washed-in soil. Posts are being tested with the 50-lb lateral pull.

Figure 4.—The plot in the more humid area near Brookings, South Dakota, has a silt loam soil with pH of 6.3. Normal annual precipitation averages about 22 inches and annual temperature about 42°F.

Penetration of each preservative into the post was measured on end-grain sections 15 inches from the top and the bottom, and at groundline, 30 inches from the butt. Measurements of both penetration and sapwood thickness were taken to the nearest 0.1 inch along two perpendicular lines that divided the section into four approximately equal areas. The sample consisted of five posts from each treatment group.

All test posts were air seasoned prior to treatment except those pressure treated with 5% pentachlorophenol (PP) and those that were butt dipped with Osmoplastic compound (OMS). The PP posts were steam seasoned in a pressure cylinder prior to treatment, whereas the OMS posts were treated while green.

Annual Inspection

An annual inspection to test the service life consisted of applying a 50-lb lateral load to each post (fig. 3). Any post that broke off when pulled or had deteriorated in the top and no longer could hold a stapled wire fence was recorded as a failure.

Results

Performance of the posts was measured by (1) survival data analysis, (2) percentage of posts that failed, (3) average service life of the failed posts, and (4) probable life of the posts (table 2). Survival data analysis (Lee 1980, Lee and Desu 1972) significantly grouped the preservative treatments by years of service within each post plot location ($p = 0.05$). The percentage of posts that failed in each treatment was the number of failed posts divided by the total number of posts in the treatment. The average service life of the failed posts was the total years of service before failure divided by the number of failed posts. The probable life of a post is an estimate of the average life through the use of mortality curves; the estimate can be made after 10% or more of the posts have failed (MacLean 1951, Blew and Kulp 1964).

Results show that during the 30-year test period no posts failed in the PP-7.1 and H&CC-9.6 treatments at either Scenic or Brookings. Other treatments with no failures were PO-0.41, PO-0.63, and VP-4.7 at the Scenic well-drained plot; PC-8.1, PC-8.6, PO-0.63, CSP-3.9, CSP-5.6, and VP-4.7 at the Scenic poorly-drained plot; and PC-8.6 at the Brookings plot.

At the Scenic well-drained plot, survival analysis indicated three performance groups of post treatments. The untreated posts with 100% failure and probable life of 13 years performed significantly less well than the treated posts. The OMS posts with 40% failures was next lowest in probable life with 34 years.

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of 27 years.

The Brookings plot had five performance groups of post treatments that were significantly different. It is obvious from the survival analysis that all of the performance groups overlapped except the untreated posts. This treatment has 100% failures with probable life of 11 years. Other treatments with 100% failures are OMS with probable life of 17 years and CSP-3.9; with probable life of 22 years.

Survival data analysis indicated that posts treated with higher retentions of the same chemical may not have greater years of service than those treated with the lower retentions. The effect of preservative retentions on the years of service also depended upon the test plot locations. The effect of preservative level may not be apparent because the actual retentions of preservative differed

Table 2.—Survival groups, percent failures, average age of failures, and probable life for each preservative treatment of fenceposts at each location.

Location Treatment	Survival groups[1]	Percent failures	Average age of failures (years)	Probable life (years)[2]
Scenic, well-drained:				
PP-7.1	a	0	—	—
PO-0.41	a	0	—	—
PO-0.63	a	0	—	—
H&CC-9.6	a	0	—	—
VP-4.7	a	0	—	—
PC-8.1	a b	4	29	—
PC-8.6	a b	8	10	—
H&CC-7.1	a b	8	9	—
CSP-5.6	a b	12	24	45
CSP-3.9	a b	16	27	44
VP-3.0	a b	18	28	41
OMS	b	40	19	34
Control	c	100	13	13
Scenic, poorly drained:				
PC-8.1	a	0	—	—
PC-8.6	a	0	—	—
PP-7.1	a	0	—	—
PO-0.55	a	0	—	—
H&CC-9.6	a	0	—	—
CSP-3.9	a	0	—	—
CSP-5.6	a	0	—	—
VP-3.0	a	0	—	—
VP-4.7	a	0	—	—
PO-0.41	a	8	22	—
H&CC-7.1	a	8	16	—
OMS	b	76	16	27
Control	c	100	11	11
Brookings:				
PC-8.6	a	0	—	—
PP-7.1	a	0	—	—
H&CC-9.6	a	0	—	—
VP-4.7	a	5	28	—
H&CC-7.1	a	8	18	—
PC-8.1	a b	20	28	41
PO-0.63	b	63	25	30
CSP-5.6	b c	61	26	30
PO-0.41	b c	79	28	27
VP-3.0	c d	74	21	28
CSP-3.9	c d	100	22	22
OMS	d	100	17	17
Control	e	100	11	11

[1] *Survival groups within each plot location with the same letter are not significantly different at the P = 0.05 level.*

[2] *The probable life of a post is an estimate of the average life through the use of mortality curves; the estimate can be made after 10% or more of the posts have failed.*

substantially from the target retentions for many of the treatments, e.g., PC-8.1 and PC-8.6 (table 1). It appears, however, that many of the treatments did not perform as well at Brookings as at the Scenic sites (table 2).

All of the post failures resulted from butt decay at or near the groundline. No posts have checked or deteriorated to the extent that fence staples would not have held.

Conclusions

Treated ponderosa pine fenceposts have a longer service life than untreated posts. Performance of the Osmoplastic butt-dip treatment is below that of the other treatments, perhaps because of limited preservative penetration of the sapwood. The poorer performance of many treatments at the Brookings site as compared to the Scenic site may be related to the higher annual precipitation at Brookings.

The equivalent uniform annual costs per post for each of the treatments are shown in table 3. These costs are for an analysis period of 30 years. The financial analysis indicates that the annual service costs for the treated and untreated posts are different depending upon the treatment, and the given assumptions as footnoted in table 3. The annual service cost of the untreated posts is the highest, ranging from $1.06 to $1.18 per post de-

Table 3.—Annual service costs of treated and untreated ponderosa pine posts at the semiarid western and humid eastern South Dakota plots.

Treatment code	Equivalent uniform annual cost per post[1]		
	Semiarid western		
	Well drained	Poorly drained	Humid eastern
	Dollars		
PC-8.1	0.85	0.85	0.86
PC-8.6	0.89	0.85	0.85
PP-7.1	0.85	0.85	0.85
PO-0.41	0.85	0.86	0.90
PO-0.63	0.85	0.85	0.86
H&CC-7.1	0.90	0.87	0.88
H&CC-9.6	0.85	0.85	0.85
CSP-3.9	0.86	0.85	0.98
CSP-5.6	0.86	0.85	0.87
OMS	0.91	1.14	1.09
VP-3.0	0.86	0.85	0.94
VP-4.7	0.85	0.85	0.85
Control	1.06	1.18	1.06

[1]*The equivalent uniform cost is based on the following:*
A capital recovery factor with 10% compound interest.
An analysis period with no salvage value of 30 years, and
An installed cost of $7.00 for untreated posts and $8.00 for the treated posts. A new post replacing a failed post was assumed to have the same service life and installed cost as the failed post.

pending upon the test plot location. The OMS posts had the next highest annual service costs per post, ranging from $0.91 to $1.06. The PP-7.1 and H&CC-9.6 posts had the lowest annual service costs at $0.85 per post.

Fenceposts currently treated with creosote, pentachlorophenol, and waterborne arsenicals are available on the market. The use of these posts are not restricted by the Environmental Protection Agency (Webb and Gjovik 1988). Present EPA restrictions apply only to the operating procedures at the treating plants. Consequently, any do-it-yourself treater has to be certified before treating wood with these chemicals.

Black Hills ponderosa pine fenceposts can be expected to perform as well as posts from other species when properly treated with perservative.

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Appendix: Treating Procedures and Chemical Composition of Preservatives

Pressure Treatments

PC: 50% petroleum distillate and 50% coal tar creosote

Posts targeted for a retention of 3 lb/ft^3 were treated as follows:

1. Posts placed in pressure cylinder.
2. Air introduced for 30 minutes and 50 psi pressure attained.
3. Preservative at 116°F introduced and 130 psi pressure applied for 20 minutes.
4. Preservative at 112°F forced back into storage tank during a 20-minute period.
5. Vacuum was drawn and applied for 30 minutes.
6. The entire charge containing 44 ft^3 of test posts and 540 ft^3 of other material retained 3.11 lb/ft^3 as reported by the plant.

Analysis of the coal tar creosote:

Sp. gr. at 38/15.5°C	1.068
Distillation: total to 210°C, %	0.3
235°C, %	6.0
270°C, %	31.8
315°C, %	60.3
355°C, %	81.9
Distillation residue above 355°C, %	17.7
Sp. gr. of fraction 235–315°C	1.039
Sp. gr. of fraction 315–355°C	1.103

Analysis of the petroleum distillate:

	°F
Initial boiling point	345
10% recovery	402
50%	476
90%	560
95%	582
98%, end point	608
Gravity, API	39.6
Flashpoint	130F +

Posts targeted for a retention of 6 lb/ft^3 were treated as follows:

1. Posts placed in pressure cylinder.
2. Steamed for 6 hours 20 minutes at 254°F.
3. Twenty-two inch vacuum drawn and held for 1 hour 55 minutes.
4. Eighty psi air pressure introduced and held for 20 minutes.
5. Preservative introduced at 181°F and 150 psi pressure applied for 20 minutes.
6. Preservative at 186°F forced back into storage tanks during 15-minute period.
7. Twenty-two inch vacuum drawn and held for 20 minutes.
8. The entire charge containing 34 ft^3 of test posts and 1237 ft^3 of other material retained 6.15 lb/ft^3 as reported by the plant.

Analysis of the coal tar creosote:

Sp. gr. at 38/15.5°C	1.070
Distillation: total to 210°C, %	2.4
(ASTM D-246–42) 235°C, %	21.8
270°C, %	46.0
315°C, %	58.9
355°C, %	75.5
Residue above 355°C, %	24.2
Coal residue, %	0.65
Water, %	0.3

Analysis of the petroleum distillate was not performed.

PP: 5% pentachlorophenol in petroleum oil

Posts targeted for a retention of 6 lb/ft^3 were treated as follows:

1. Posts placed in pressure cylinder.
2. Steamed for 8 hours at 254°F.
3. Twenty-two inch vacuum drawn and held for 1 hour 40 minutes.
4. Eighty psi air pressure introduced and held for 25 minutes.
5. Preservative introduced at 166°F and 150 psi pressure applied for 25 minutes.
6. Preservative at 166°F forced back into storage tanks during a 25-minute period.
7. Twenty-two inch vacuum drawn and applied for 30 minutes.
8. The entire charge containing 34 ft^3 of test posts and 1242 ft^3 of other material retained 6.27 lb/ft^3 of preservative, as reported by the plant.

Analysis of the pentachlorophenol salts:

	Percent
Pentachlorophenol	84
Other chlorophenols	10
Petroleum distillates	2
Inert materials	4

The treating solution contained 5% pentachlorophenol in a carrier solution of 55% No. 2 furnace oil and 45% gas oil.

PO: Osmosalts

Posts targeted for a retention of 0.35 lb/ft^3 were treated as follows:

1. Posts placed in pressure cylinder.
2. Four-inch vacuum drawn.
3. Steamed for 4 hours 10 minutes with a maximum of 20 psi for 3 hours 20 minutes.
4. Nineteen-inch vacuum drawn in 40 minutes and held for 10 additional minutes.
5. Twenty-three psi of air pressure applied for 20 minutes.
6. Preservative introduced at 90°F and pressure applied for 1 hour 20 minutes with a maximum of 116 psi for 50 minutes.
7. The entire charge containing 49 ft^3 of test posts and 87 ft^3 of other material retained 0.35 lb of $salt/ft^3$ as reported by the plant.

Analysis of the Osmosalts:

	Percent
Sodium bichromate	32.3
Sodium fluoride	33.0
Disodium arsenate	25.0
Dinitrophenol	6.3
Inertingredients	3.4

The treating solution contained 1.5% Osmosalts by volume.

Posts targeted for a retention of 0.55 lb/ft^3 were treated as follows:

1. Posts placed in pressure cylinder.
2. Five-inch vacuum drawn.
3. Steamed for 4 hours-10 minutes with a maximum of 20 psi for 3 hours.
4. Nineteen-inch vacuum drawn in 1 hour and held for 10 additional minutes.
5. Twenty-three psi of air pressure applied for 20 minutes.
6. Preservative introduced at 90°F and pressure applied for 1 hour 10 minutes with a maximum of 116 psi for 50 minutes.
7. The entire charge containing 49 ft^3 of test posts and 123 ft^3 of other material retained 0.55 lb of $salt/ft^3$.

The treating solution contained 2.25% Osmosalts by volume.

Nonpressure Treatments

H&CC: Hot and cold bath in 100% coal tar creosote

Posts targeted for a retention of 3 lb/ft^3 were treated as follows:

1. Posts placed in an open tank of coal tar creosote oil.
2. Hot treatment applied for 5¼ hours with temperatures above 200°F for 2¼ hours.
3. Cold treatment applied for 3 hours with temperatures between 138 and 145°F.
4. The entire charge containing 44 ft^3 of test posts and 208 ft^3 of other material retained 3.56 lb/ft^3 as reported by the plant.

Analysis of the coal tar creosote oil:

Sp. gr. at 38/15.5°C	1.086
Water	0.7
Distillation: total to 210°C, %	0.8
235°C, %	7.1
270°C, %	31.7
315°C, %	54.3
Distillation residue above 355°C, %	78.0
Sp. gr. of fraction 235–315°C	1.036
Sp. gr. of fraction 315–355°C	1.129

Posts targeted for a retention of 6 lb/ft^3 were treated as follows:

1. Posts placed in tank of creosote.
2. Hot treatment applied for 9½ hours with temperatures above 250° for 8 hours.
3. Cold treatment applied for 3 hours with temperatures between 145 and 165°F.
4. The entire charge containing 44 ft^3 of test posts and 391 ft^3 of other material retained 6.55 lb/ft^3 as reported by the plant.

Analysis of the coal tar creosote oil: Same as for the 3 lbs/ft^3 treatment.

CSP: Cold soak, 5% pentachlorophenol in petroleum oil

Posts targeted for a retention of 3 lbs/ft^3 were treated as follows:

1. The posts were submerged in a tank of treating solution for 23 hours. The temperature of the solution ranged from 61 to 65°F during treatment.

Analysis of the pentachlorophenol concentrate mixture:

	Percent
Pentachlorophenol	34
Other chlorophenols and related compounds	6
Petroleum distillate	27
Inertingredients	33

The treating solution was 110 gallons of pentachlorophenol concentrate mixed with 110 gallons of No. 2 fuel oil.

Posts receiving a target retention of 6 lb/ft^3 were treated as follows:

1. The posts were submerged in a tank of treating solution for 90 hours. The temperature of the solution ranged from 61 to 68°F during treatment. These 6 lb/ft^3 posts were treated with the same chemical solution as the 3 lb/ft^3 posts.

OMS: Osmoplastic, butt dip only

Posts receiving an unknown retention of 50% Osmoplastic compound and 50% Avenarius Carbolineum were treated as follows:

1. The butts were dipped to a depth of 3 feet for 5 to 10 seconds in a drum of 212°F preservative.
2. The posts were stacked in tight piles after the butts had drained for 5 minutes.

Analysis of the Osmoplastic compound:

	Percent
Sodium fluoride	43.7
2,4-dinitrophenol	3.1
Potassium bichromate	2.0
Inertingredients	51.2

Analysis of the Avenarius Carbolineum:

	Percent
High boiling coal tar oils	97.0
Inertingredients	3.0

VP: Vacuum, 5% pentachlorophenol in petroleum oil

Posts targeted for a retention of 3 lbs/ft^3 were treated as follows:

1. Posts placed in vacuum tank.
2. Initial vacuum of 15 inches drawn and held for 1 hour 30 minutes.
3. Preservative at 90°F drawn into tank under vacuum of 15 inches.
4. Vacuum released and posts soaked for 30 minutes.
5. Tank drained and recovery vacuum of 23 inches maintained for 1 hour.

The treating solution contained 4.8% pentachlorophenol. No further analysis was performed.

Posts targeted for a retention of 6 lb/ft^3 were treated similarly as those with a target retention of 3 lb/ft^3 except the soak time was 1 hour 30 minutes instead of 30 minutes.

Markstrom, Donald C.; Gjovik, Lee R. 1992. Service life of treated and untreated Black Hills ponderosa pine fenceposts. Res. Pap. RM-300. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 9 p.

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Keywords: Fenceposts, preservatives, service life, *Pinus ponderosa*

Rocky Mountains

Southwest

Great Plains

U.S. Department of Agriculture
Forest Service

Rocky Mountain Forest and Range Experiment Station

The Rocky Mountain Station is one of eight regional experiment stations, plus the Forest Products Laboratory and the Washington Office Staff, that make up the Forest Service research organization.

RESEARCH FOCUS

Research programs at the Rocky Mountain Station are coordinated with area universities and with other institutions. Many studies are conducted on a cooperative basis to accelerate solutions to problems involving range, water, wildlife and fish habitat, human and community development, timber, recreation, protection, and multiresource evaluation.

RESEARCH LOCATIONS

Research Work Units of the Rocky Mountain Station are operated in cooperation with universities in the following cities:

Albuquerque, New Mexico
Flagstaff, Arizona
Fort Collins, Colorado*
Laramie, Wyoming
Lincoln, Nebraska
Rapid City, South Dakota
Tempe, Arizona

*Station Headquarters: 240 W. Prospect Rd., Fort Collins, CO 80526